Fuels, Engines, and Emissions

In-Cylinder Hydrogen Generation May Enhance Catalyst Function

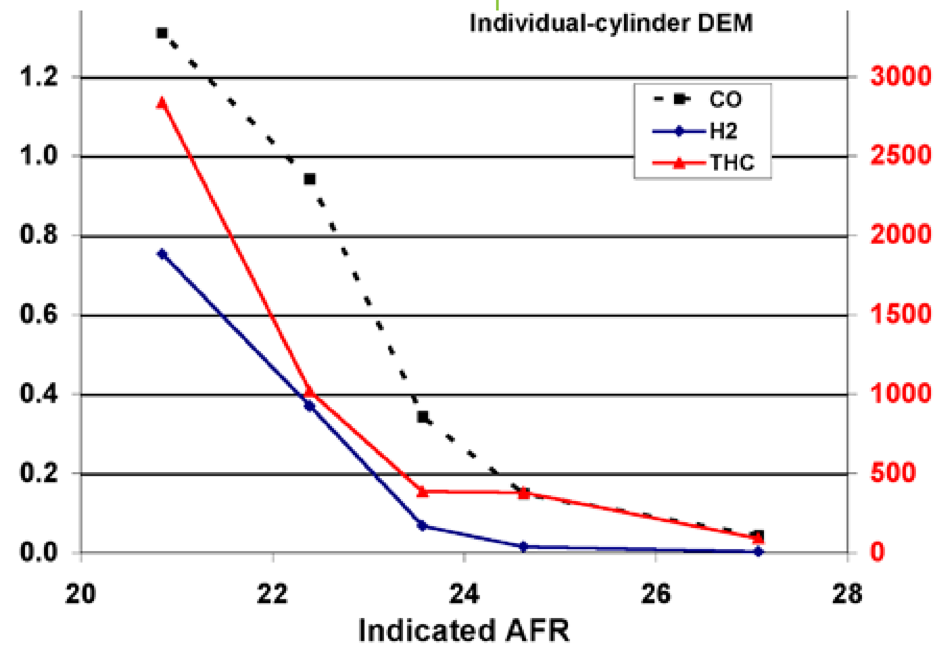

Figure 1. *Measured levels of H_2, CO, and total HC in engine-out exhaust at various net air-fuel ratios using an individual-cylinder delayed and extended main (DEM) fuel injection strategy.*

Background

New low temperature combustion (LTC) regimes are being investigated as a means to improve the efficiency of diesel engines. The lower engine-out nitrogen oxide (NO_x) emissions in LTC modes can remove some burden from post-combustion emissions controls and reduce the fuel penalty associated with NO_x reduction. In addition, new combustion regimes that will improve brake-specific fuel consumption are being sought.

However, while these combustion regimes will be exploited to whatever extent possible in future production engines, diesels are still expected to run in the more conventional modes at certain operating conditions. The wide range of operating conditions provides a challenging environment for the aftertreatment system. Multi-mode operation of the engine will almost certainly require a multi-mode aftertreatment system.

While lean NO_x trap (LNT) and urea SCR (selective catalytic reduction) technologies show great promise in reducing NO_x under conventional diesel combustion conditions, the lighter-load, low-NO_x LTC regimes may require different catalyst technology. Treatment of HC (hydrocarbon) and CO (carbon monoxide) emissions during LTC is also a concern. Because of the relatively high HC to NO_x ratio in LTC modes, HC SCR may be an attractive option to augment the LNT or urea SCR systems. In recent

Benefits

- Better understanding of low-temperature combustion regimes.
- Enables efficient, clean diesel engines in light-duty applications.

H_2 in the feedgas. On-board fuel reformers are being researched as a potential way to generate H_2 for the aftertreatment system.

In a previous LNT research activity, engineers at ORNL developed regenerating strategies for LNTs using a rapid prototype engine controller. While the diesel engine normally runs fuel lean [with an air to fuel ratio (AFR) typically much greater then 14.5], the LNT requires a periodic rich excursion, a short duration pulse in which the AFR dips below 14.5. The rich, or reducing, conditions allow release and reduction of the stored NO_x on the LNT. One strategy for this rich excursion is the "delayed and extended main" or DEM, in which the main fuel pulse is delayed in crank angle time and extended into the rich regime.

Technology

This project's goal was to leverage existing combustion and aftertreatment R&D at ORNL and collaborate with industry partners to develop and characterize advanced catalysts. The project investigated a means of generating H_2 and other reformate products in the engine cylinders.

Recent publications have shown that H_2 can promote the catalytic reduction of NO_x in HC-SCR catalysts operating in the lean regime. With this knowledge, researchers at ORNL modified the DEM strategy to investigate reformate production under net-lean conditions. The investigated approach makes use of individual cylinder control. The "individual cylinder DEM strategy" commands one cylinder to run rich while the other three run lean. The rich cylinder is indexed from one cylinder to the next with only one cylinder in the rich regime at any given time.

Status

With the individual cylinder approach, researchers have proved that up to 0.8% H_2, over 1% CO, and 3,000 ppm (parts per million) HC can be produced under net lean conditions with over 9% O_2 still present in the exhaust. Preliminary experiments have shown that this unusual combustion approach can accelerate catalyst light-off. Future experiments will investigate the promotional effects of these exhaust species on catalyst function.

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